Soil Contamination of Leachates from Wood Preservative and Agropesticides Affecting Seed Germination

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DECLARATION

I hereby declare that the Final Year Project 2013 is based on my original work excepts for quotations and citations, which have been duly acknowledged also, declare that it has not been or concurrently submitted for any other degree at UNIMAS or institutions of higher learning

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LIST OF ABBREVIATIONS

U.S. EPA	United State Environmental Protection Agency
CCA	Copper Chromium Arsenate
OECD	Organization for Economic Cooperation and Development
LC50	Lethal Concentration
ISTA	International Seed Testing Association
LD50	Lethal Dose
LOSP	Light Organic Solvent Preservative

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ABSTRACT

The purpose of this study was to compare the effects of the concentrations of CCA preservatives and agropesticides such as Chlorpyrifos, Cypermethrin and Permethrin. Two seed species, okra (*Abelmoschusexculentus*) and tomato (*Solanumlycopersicum*) were used for this experiment. The seed species were germinated with different concentrations of CCA preservative, Chlorpyrifos, Cypermethrin and Permethrin which are being treated in filter paper and soil. 4 replicated were done for all the treatments. The seed germinations testing were evaluated for seven consecutive days. The total of the seed germinated were recorded and the mean were obtained. It was found that there is interaction between the chemicals however it was not scientifically practical to compare the chemicals because the concentrations for each chemical are different. Thus, individual chemical was compared at their concentration levels. In most cases, we can see that the numbers of germinating seeds are decreasing as we increase the concentration. It is also found that as the concentration of chemical increases, the pH value also decreases. In another word, the higher the concentrations of the chemicals, the more acidic it is. This phenomenon can explain why the seeds are acting negatively on its germination due to the unfavourable acidity. If we were to compare the effectiveness of agrochemicals on the prohibition of seed germination, CCA is found to be highly phytotoxic to the seeds. No germination is detected when 6% of CCA solution is used. Chlorpyrifos of higher concentrations also prohibited the seed germinations.

Keywords: Effects of concentrations, seed germination, filter paper, soil, phytotoxic.

ABSTRAK

Tujuanpengajianiniadalahuntukmembandingkankeberkesananpengawetkayujenis CCA, danracunperosaksepertiChlorpyfifos, Cypermethrin, Permethrinpadatahapkonsentrasi yang berbeza.Duajenisbijibenisiaitukacangbendi (Abelmoschusexculentus) dan tomato (Solanumlycopersicum) telahdigunakandalameksperimenini.Bijibenihtersebutdisemai di ataskertas filter dan di dalamtanahdenganmengunakanpengawetkayudanracunperosakpadatahapkepekatan yang berbeza. Percambahanbijibenihdipantauselamatujuhhariberturut-turutdannilaijumlahpercambahanbijibenihsertapuratapercambahandicatatkan.Pengawetkayudanracunperosakditemuimempuyaiinteraksisesamakimiatersebutnamundarisegicarasaintifiknya, keberkesananantarapengawetkayudanracunperosaktidakpatutdibandingkan. Olehitu, perbandinganantaratahapkepekatanpadasetiapjeniskimiatelahdilakukan.Secaraumumnya, jumlahpercambahanbijibenihdidapatimenurunapabilatahapkepekatankimiaditingkatkan.Peningkatantah apkepekatanpadasetiapkimiatelahmenyebabkannilai pH solusimenurunbermaknasolusitersebutmenjadiasidikapabilatahapkepekatanditingkatkan.Fenomenainida patmenjelaskanbahawapenurunanpercambahanbijibenihapabilatahapkepekatanditingkatkan.Bijibenihtid akberupayauntukbercambahdalamsituasi yang asidik.CCA didapatimerupakankimia yang sangattoksiksehinggamembantutkanpercambahanbijibenih.Chlorpyfirospadatahapkepekatan yang tinggijugamembantutpercambahanbijibenih.

Kata Kunci: Keberkesannantahapkepekatan, percambahanbijibenih, kertas filter, tanah, toksiksititerhadaptumbuhan.

1.0 INTRODUCTION

Application of wood as building materials have been widely used since the beginning of the human civilization. Abundant resources and multitude uses of wood make it a renowned and important resource throughout human history. Wood is composed of cellulose, lignin, hemicelluloses and about 5% to 10% of extractable materials within its cellular structure (Brender et al., 1999).

Till now, the application of wood in agriculture sector is still one of the most important building materials used by the local farmers. They use woods for wooden fences, and building hut to store their harvests. According to Tao (2012), wood material that is used for outdoor application is usually treated with preservatives. Wood preservatives are chemicals that are used to protect wood from decomposed by insects and fungi (Tao, 2012).

The most effective insecticide and fungicide of wood preservatives are copper, chromium and arsenate. According to Tao (2012), most of the woods used in outdoor settings have been treated using chromated copper arsenate (CCA). CCA Type C is usually used to treat the woods. CCA Type C contains 47.5% CrO_2, 18.5% of CuO and 34% As_2O_5 (Tao, 2012; Barrie, 2000). However in U.S.A since December 2003, all wood manufacturers are prohibited to treat wood with CCA preservative. CCA preservative has been declared carcinogenic to human health by the United State Environmental Protection Agency (U.S. EPA, 2003 as cited in Quarles, Kobzina, & Geisel, 2004).

Although CCA preservative is at best in controlling pests and fungi but the leaching of the trace elements, arsenic (As), copper (Cu), and chromium (Cr) into the soil by precipitation could leave adverse impact to the environment (Barrie, 2000). Besides that, a recent study

has concluded that arsenic is indeed being leached out from the CCA preservative (Solo-Gabrielle et al., 2004).Studies found that the mobility of arsenate is similar to phosphate which is taken up by the plant roots (Australian Pesticide and Veterinary Medicines Authroity [APVMA], 2005b). However the uptake of arsenic varies with the plant species. Due to the carcinogenic effect of CCA preservative, wood manufacturers tend to find other alternatives to substitute the usage of CCA preservatives.

In agriculture sector, agropesticides play an important role in enhancing the productivity and agricultural yield. Agropesticides are chemicals designed to be used in the agriculture sector to control, reduce and repel the infestation of pest and diseases besides promoting the yield of agriculture productions. According to Dung et al. (2003), the applications of agropesticides tend to increase in developing countries where the advantages are yet to be fully understood. Many farmers use urea extensively as organic fertilizer and as a result of imbalanced fertilizer use. Hence, this could be a source of increasing pesticide usage (Dung et al., 2003). There are various types of agropesticides such as insecticides, fungicides, herbicides, organophosphates, organochlorine, carbamates and pyrethroids.

Application of agropesticides in plantation sectors indeed brings beneficial impact to the economy as well as the farmers. However, extensive use of agropesticides in a long-run could also bring negative effects to the environment. Many agropesticides are hardly degradable and may persist in soil, leached to the groundwater source which indirectly contaminate wide environment (Pesticide Action Network [PAN] Europe, 2010). According to PANEurope (2010), agropesticides can enter and accumulate in the food chain and affect human health.

To summarize, the application of CCA preservative and agropesticides bring benefits to the applicants however it also brings deleterious effect of the environment. Thus, environmental impact assessment should be carried out on each type of wood preservative and agropesticides which also used in wood protection, so that the toxicity database would be useful for the applicants.

The extensive usage of CCA preservative and agropesticides in the agriculture sector might be a major concern for the environmentalists. The leachates from treated wood could contaminate the soil and affect the germination plant seeds. Therefore more studies are to be carried out to understand better of the physical fates of CCA preservative and agropesticides. Indirectly, the outcome of this study could help the farmers to use the agropesticides more wisely and environmental-friendly.

The objectives for this project are:

1. To investigate the germination rate of *Abelmochusesculentus*(okra) and *Solanumlycopersicum* (tomato) seeds under different concentration of CCA preservative, Chlorpyrifos, Cypermethrin and Permethrin on filter paper and in contaminated soil.
2. To study the LC50 of *Abelmochusesculentus*(okra) and *Solanumlycopersicum* (tomato) seeds under different concentration of CCA preservative, Chlorpyrifos, Cypermethrin and Permethrin on filter paper and in contaminated soil.

2.0 LITERATURE REVIEW

2.1 Toxicology

Toxicology is the study of the harmful effects of chemicals on living organisms (Whitford, Fuhremann, Rao, Arce, &Klaunig, n.d.). Toxicological testing is an evaluation of effect on short-term or long-term exposure of agropesticides affecting the experimental organism. According Whitford et al. (n.d.), toxicological assessment are conducted with experimental animals which exposed to different levels of agropesticides for different length of time. Studies from these experimental animals allow toxicologists to relate the harmful effect on various toxicity level of pesticide to human health.

2.2 Ecotoxicology testing

Ecotoxicological methodologies used to analysis chemicals were introduced to deal with chemicals entering the environment (Hillbeck, Jänch, Meier, &Römbke, 2008). OECD had initiated the Chemicals Testing Program to standardize the test requirements and avoid trade barriers. Based on Hillbeck et al. (2008) many countries have recognized the OECD in their national legislation and policy. Besides that, the OECD test methods are remarkable source in U.S. EPA.

Standardized guidelines for chemical testing follow a hierarchical order. The common test order consists of simple, short-term and low-cost species test. The tests are performed under worst-case conditions. The aim is to determine the effects of one or repeated application of test substance over various range of concentrations. LC_{50} or EC_{50}value is usually used to summarize the test results where, LC is Lethal Concentration and LD is Lethal Dose at which 50% of the experimental organisms die. Ecotoxicology focus more

on species levels as well as the impact of chemicals possess on the ecosystems (Persoone&Gillet, 1990).

2.3 Wood Extractives

Wood extractives and resins constitute approximately about one to four percent of the chemical compounds exist in the wood (Golander, 2011). According to Croon (1969 as cited in Golander, 2011), wood extractives chemically can occur in various forms such as aliphatic hydrocarbons, alcohols, acids, waxes, fats, terpenoidic substances, phenol, glycosides, quinones, protein and carbohydrates. Most of the wood extractives are non polar, possess low molecular weight and have different chemical mechanisms. Wood parenchyma cells store these extractives. Moreover, the extractives that serve as wood natural preservatives are found in the resin canal and adherent epithelial cells (Wålinder, 2000 as cited in Golander, 2011). According to Hillis (1971 as cited in Golander, 2011), more amount of extractives can be found in the dark heartwood as compared to the lighter sapwood. Besides that, when the tracheids filled with extractives, it converts sapwood into heartwood (Hillis, 1971 as cited in Golander, 2011). Indirectly this phenomenon gives the heartwood and all the dead cells a natural protection.

2.4 CCA preservative

Copper chromium arsenate (CCA) is a chemical substance used to protect the wood from decomposed or infestations of insects and fungi. CCA is registered under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) by the United State Environmental Protection Agency (EPA). CCA preservative is also used to produce pressure treated wood (Barrie, 2010). CCA is believed to be the most effective insecticide and fungicide of wood

preservatives. CCA Type C is usually used to treat the woods. CCA Type C contains 47.5% CrO_2, 18.5% of CuO and 34% As_2O_5 (Tao, 2012; Barrie, 2000).

According to Tao (2012), most of the woods used in outdoor settings have been treated using chromated copper arsenate (CCA). Wood materials used before 2004 are mainly pressure-treated with CCA preservatives. Besides that, most of the structural applications such as retaining walls, playground structures and woods used in external environment and are pressure-treated with CCA preservative (Quarles et al., 2004). According toQuarles et al. (2004), most of the CCA treated wood is green in colour, sometime it does contain staining which eventually making the wood a brownish colour.

However CCA preservative is prohibited by United State Environmental Protection Agency (U.S. EPA) on 2004 due to carcinogenic effect liberated. The leaching of the trace elements, arsenic (As), copper (Cu), and chromium (Cr) into the soil by precipitation can cause severe problems to the environment (Carey et al., 1996; Cooper and Ung, 1997; Lebow, 1996; Stilwell and Gorny, 1997; Solo-Gabriele et al., 2000 as cited in Barrie, 2000). Besides that, a recent study has concluded that arsenic is indeed being leached out from the CCA preservative (Solo-Gabrielle et al., 2004).

Studies also found that the mobility of arsenate is similar to phosphate which is taken up by the plant roots (APVMA, 2005b). However the uptake of arsenic varies with the plant species. Due to the carcinogenic effect of CCA preservative, wood manufacturers tend to find other alternatives to substitute the usage of CCA preservatives.

2.5Agropesticides

In agriculture sector, agropesticides play an important role in enhancing the productivity and agricultural yield. Agropesticides are chemicals designed control, reduce and repel the infestation of pest and diseases besides promoting the yield of agriculture productions. Many farmers use urea extensively as organic fertilizer and as a result of imbalanced fertilizer use. According to Dung et al. (2003), the applications of agropesticides tend to increase in developing countries where the advantages are yet to be fully understood. In 1995, Ministry of Agriculture and Rural Development reported that currently farmers has used 200 different insecticides, 83 fungicides and 52 herbicides, organophosphates, carbamates, and pyrethroids. Hence, this could be a source of increasing pesticide usage (Dung et al., 2003). There are various types of agropesticides such as insecticides, fungicides, herbicides, organophosphates, carbamates and pyrethroids.

Application of agropesticides in plantation sectors indeed brings beneficial impact to the economy as well as the farmers. However, extensive use of agropesticides in a long-run could also bring adverse effects to the environment. Many agropesticides are hardly degradable. Besides that, they may persist in soil, leached to the groundwater source which indirectly contaminate wide environment (PANEurope, 2010). According to PANEurope (2010), agropesticides can enter and accumulate in the food chain and affect human health. Some of the commonly used agropesticides are described below. However, depending on the wood extractives alone as natural wood preservatives are not effective enough to protect the wood. Thus, wood scientists resort to these agropesticides as chemical preservatives to protect the wood.

2.5.1 Chlorpyrifos

Chlorpyrifos is an organophosphate insecticide which has been utilized widely at home and in the farm. Chlorpyrifos is a white crystal-like solid with a strong smell (Richer &Navara, 1997; National Pesticide Information Centre[npic], 2010). It is partially soluble in water, so usually Chlorpyrifos is mixed using oily liquids before applied to crops and animals. The application of Chlorpyrifos at home is to control vectors such as cockroaches, fleas and termites (Richer &Navara, 1997). Based on Richer and Navarro (1997) Chlorpyrifos is used to control ticks on cattle and act as pesticide to repel crop pest in the farms.

Chlorpyrifos was first registered as insecticide in 1965 and U.S. EPA re-registered it in 2006. Commercial pesticides such as Dursban® and Lorsban® also contain Chlorpyrifos as their active ingredients.

In wood industry, Chlorpyrifos is widely used as wood preservative to prevent wood-infesting insects such as beetles, Carpenter ants, Carpenter bees and termites (NufarmChlorpyrifos SPC 2 Insecticide, 2010). According to NufarmChlorpyrifos SPC 2 Insecticide (2010), to control the manifestation of wood-infesting ants, Chlorpyrifos is applied around cracks or crevices, and areas where ants can enter or hide. For termites' controls, Chlorpyrifos will kill the worker termites. Most of the Chlorpyrifos used to treat wood fences and utility poles since it can repel termites (npic, 2010). Besides that, Chlorpyrifos has served as one of the widely used wood preservative in Japan for the past few years (Kurata, Watanabe, Ono, & Kawamura, 2005).

2.5.2 Cypermethrin

Cypermethrin is an insecticide which belongs to the pyrethroid family. It was first commercialized in 1977. The common products which contain Cypermethrin as active ingredient are Demon, Cymbush, Ammo and Cynoff. Most of the Cypermethrin is used in cotton industry. It is mainly used to kill insects on cotton. According to Cox (1996), Cypermethrin also used to kill pest like cockroaches and termites.

Cypermethrin is a contact poison. It kills insects by disrupting the normal function of the nervous system. Cypermethrin also believe to cause convulsion and excitability (Cox, 1996). It also affects functionality of certain neuro enzymes such as monoamine oxidase which breaks down neurotransmitters.

Cypermethrin is an insecticide which also applicable used as wood preservative. Most of the Cypermethrin is used in preventive and remedial treatment (Cypermethrin, 2010). Cypermethrin is effective in controlling *Hylotrypesbajulus* (furniture beetle), *Anobiumpunctatum* (house longhorn beetle) and *Reticulitermessantonesis*(termites) (Cypermethrin, 2010). According to Waldvogel and Alder (n.d.) found that for termite drywood species, Cypermethrin (Demon TC) is coarse spray or inject into wood for localized infestation.

Van Acker, Stevens and Pallaske (1990) found that Organic insecticides such as lindane or cypermethrin gave the best results, with nearly no attack of *Lyctus* (wood bettle) for plywood.It proves that cypermethrin is indeed a good preservative use to repel insects.

2.5.3 Permethrin

Permethrin is an insecticide which contain pyrethroid compound (Imgrund, 2003; & Beyond Pesticides, 2004). It is also a non-systemic and broad spectrum insecticide. According to Imgrund (2003), Permethrin is mainly used as insecticide, termiticide and some wood preservatives. Permethrin was registered with US EPA and was commercialized in year 1977 (National Pesticide Telecommunications Network[NPTN], 1997). It is also commonly used at home and garden as insecticide and treatment for ectoparasites such as fleas and lices (Beyond Pesticides, 2004).

Permethrin is very efficient in killing pests. According to Imgrund (2003), Permethrin is a contact poisons which dependent on disturbance of axonic nerve impulse conduction, causing immediate paralysis and death. According to NPTN (1997), Permethrin kills insects when have direct contact with it besides it is believed to have repellant effect. Permethrin also believed to be very effective against the growth stages of insects especially larvae (NPTN, 1997).

Commercial products such as Nix, Elimite, Prelude, Combat, Ambush, Dragnet, Outflank and Pethrine contain Permethrin as their active ingredients (Beyond Pesticides, 2004). Permethrin can be in many forms such as dusts, fogs, sprays and emulsifiable concentrates and creams.

Permethrin is a synthetic pyrethyroids insecticide which is use as preventive and curative against wood boring insects and termites (Janssen Preservation and Material Protection, 2011). Pinniger and Child (1996) found thatPermethrin and Cypermethrin is the active

ingredient in most insecticides which are used to treat *Anobiumpunctatum* (furniture beetle). Permethrin has relatively low mammalian toxicity with high in insecticidal properties which only little dosage is required for the treatment. Treamtments against woodborers are carried out by applying insecticide diluted to the treatment surface (Pinniger& Child, 1996).

In Light Organic Solvent Preservatives (LOSP), Permethrin is usually used as active ingredient (a.i.). Usually the proportion of Permethrin in LOSP is less than 0.1% w/w. (Material Safety Data Sheet [MSDS] H3 LOSP, 2007). LOSP treatment is used to protect timber from attack from termites, insects and fungal decay. Most of the timber is used for exterior foundation and structural application above the grounds (MSDS H3 LOSP, 2007).

2.6. Effect of different chemicals

According to Oxford Online Dictionary, leachate is defined as water that has percolated through a solid and leach out some of the constituents. The chemical constituents of CCA preservative in pressure-treated wood and agropesticides such as Chlorpyrifos and Permethrin may leach out of treated wood due to heavy rainfall or flooding. The heavy metals such as copper, chromium and arsenate can leach to the groundwater not only causing toxic to the aquatic biota but also severe impact to the environment. Besides that, heavy metals can also bioaccumulating in the food chain which is carcinogenic to humans.